

Name:   
ID:

**CSCI 3104, Algorithms**  
**Problem Set 1 – Due Jan 24 11:55pm**

**Profs. Chen & Grochow**  
**Spring 2020, CU-Boulder**

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*Advice 1:* For every problem in this class, you must justify your answer: show how you arrived at it and why it is correct. If there are assumptions you need to make along the way, state those clearly.

*Advice 2:* Informal reasoning is typically insufficient for full credit. Instead, write a logical argument, in the style of a mathematical proof.

**Instructions for submitting your solutions:**

- The solutions **should be typed** and we cannot accept hand-written solutions. Here's a short intro to L<sup>A</sup>T<sub>E</sub>X.
- You should submit your work through the **class Canvas page** only.
- You may not need a full page for your solutions; pagebreaks are there to help Gradescope automatically find where each problem is. Even if you do not attempt every problem, please submit this template of at least 9 pages (or Gradescope has issues with it).

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1. *What are the three components of a loop invariant proof? Write a 1–2-sentence description for each one.*

**Initialization:** The loop invariant is true prior to the first iteration of the loop.

**Maintenance:** If the loop invariant is true before iteration  $i$  of the loop, it remains true before iteration  $i + 1$ .

**Termination:** When the loop terminates, the invariant gives us a useful property that helps show that the algorithm is correct.

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2. *Identify and state a useful loop invariant in the following algorithms. You do not need to prove anything about it.*

(a)     `FindMinElement(A) : //array A is not empty`  
         `ret = A[length(A)]`  
         `for i = 1 to length(A)-1 {`  
             `if A[length(A)-i] < ret{`  
                 `ret = A[length(A)-i]`  
             `}}`  
         `return ret`

Prior to the start of iteration  $i$ :

$\text{ret} = \min\{A[n], A[n-1], \dots, A[n-i+1]\}$

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(b) LinearSearch(A, v) : //array A is not empty and has no duplicates
    ret = -1 //index -1 implies the element haven't been found yet
    for i = 1 to length(A) {
        if A[i] == v{
            ret = i
        }
    }
    return ret
```

Prior to the start of iteration  $i$ :

If the query element  $v$  is in  $A[1..i-1]$  at position  $k$ , then  $\text{ret} = k$ , and otherwise  $\text{ret} = -1$

